Forest Insect
& Disease
Leaflet 1

U.S. Department
of Agriculture
Forest Service

Western Pine Beetle

Clarence J. DeMars, Jr.,[1] and Bruce H. Roettgering[2]

F-703000

The western pine beetle, *Dendroctonus brevicomis* LeConte, can aggressively attack and kill ponderosa and Coulter pine trees of all ages and vigor classes that are 6 inches (15 cm) or larger in diameter, including apparently healthy trees. Group killing of trees is common in dense, overstocked stands of pure, even-aged, young sawtimber (fig. 1), but also occurs among dense clumps of pine in stagnating mixed-conifer stands. One million or more trees containing more than 1 billion board feet of timber may be killed each year during an outbreak. Such extensive tree killing may deplete timber supplies, adversely affect levels and distributions of stocking, disrupt management planning and operations, and increase forest fire danger by adding to available fuels.

F-703001

Figure 1.—*Group tree killing by western pine beetle in a dense, young-growth ponderosa pine stand.*

Usually, the beetles breed in and kill scattered, overmature, slow-growing, decadent, or diseased trees and trees weakened by stand stagnation, lightning, fire, or mechanical in-

[1]Research Entomologist, U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

[2]Supervisory Entomologist, U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, San Francisco, Calif.

jury. This tree mortality need not be a loss, but may be considered part of the normal ecological process of succession through which a forest matures and replaces itself. Some of the trees killed under these conditions, however, may be on residential or recreation sites. These highly prized trees are often impossible to replace and expensive to remove.

The western pine beetle is most damaging in California, but its range extends northward into Oregon, Washington, Idaho, and southern British Columbia; eastward into Montana, Nevada, Utah, Colorado, Arizona, New Mexico, and western Texas; and southward into northwestern Mexico (fig. 2). It is commonly found in forests with a mid-elevation level between 2,000 and 6,000 feet (600 to 1,800 m). In Canada, beetle populations can be found below 1,000 feet (300 m) and in Mexico above 8,000 feet (2,400 m).

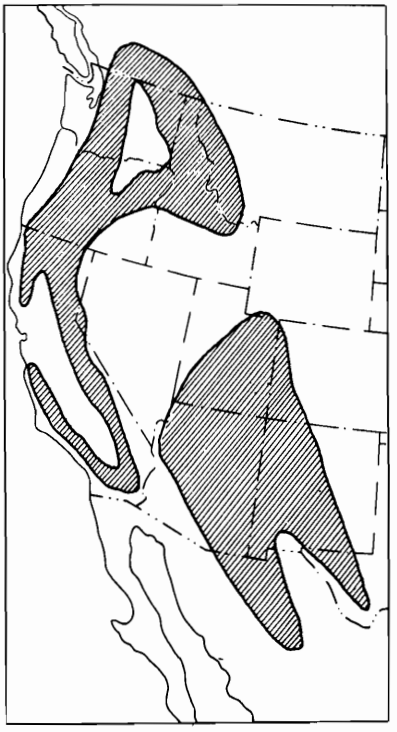


Figure 2.—*Range of the western pine beetle.*

Hosts, Damage, and Evidence of Attack

Normal attack and development occur only in ponderosa and Coulter pine. Pitch tubes, ¼ to ½ inch (6 to 13 mm) in diameter, formed on the tree trunk around entry holes made by attacking female beetles (fig. 3), are usually the first evidence of infestation. The pitch tubes are white to red-brown masses of resin and boring dust found in the crevices between the bark plates. Relatively few, widely scattered, white pitch tubes, 1 inch (25 mm) or larger in diameter, usually indicate that the attacks were not successful and that the tree will survive. Close examination of successfully attacked trees, however, reveals small, reddish-brown pitch tubes and dry, reddish-brown boring dust in the bark crevices and around the base of the tree.

The western pine beetle initially attacks midway up the tree, but the first sign of attack may often be predaceous checkered beetles seen at eye level scurrying over the bark in search of western pine beetle prey.

Attacking adult beetles carry spores of a blue-staining fungus, *Ceratocystis minor* (Hedg.) Hunt, in special pouch-like structures in their heads called mycangia. As the beetles chew their way through the bark, the spores of this wilt-causing fungus dislodge and begin to germinate. In trees

A F-703002

B F-703003

Figure 3.—*Pitch tubes made by the western pine beetle: (A) unsuccessful attack, a pitched-out beetle (ejected by resin flow) stuck to underside of pitch tube; and (B) successful attack, a small, red-brown tube with clear opening.*

attacked in early or midsummer, it takes only a few weeks for the fungus to invade and block the conductive vessels of the inner bark and sapwood. Once the vessels are blocked, the foliage begins to fade, first to a pale green and then to yellow, straw, and sorrel. Finally, perhaps after a year, the foliage may turn red brown. This fading is the first evidence of damage to the tree that is visible at a distance.

In trees attacked in late summer or fall, the fungus develops more slowly, and many infested trees do not fade until the next spring. These green trees are often first seen to be infested when woodpeckers flake off the outer bark as they search for and feed on developing beetle larvae. This flaking exposes the bright-orange inner bark, making these trees visible from as far away as 300 feet (100 m) (fig. 4.).

F-703004

Figure 4.—*To feed on a western pine beetle brood, woodpeckers have stripped off the outer bark of the tree, exposing the orange inner bark.*

Western pine beetle infestation of a dying pine can be confirmed by removing the bark to expose the winding, crisscrossing egg galleries in the inner bark and on the surface of the sapwood (fig. 5). The egg galleries are slightly wider than the adult beetles that construct them and are usually tightly packed with boring dust. The western pine beetle is the only bark beetle that makes this particular type of egg gallery in ponderosa and Coulter pines.

F-703005

Figure 5.—*Sinuous egg galleries characteristics of the western pine beetle in ponderosa and Coulter pine.*

Life Stages and Development

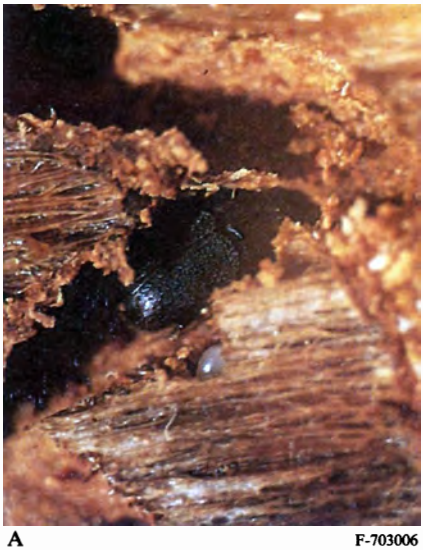
Western pine beetles pass through the egg, larval, pupal, and adult stages during a life cycle that varies in length from about 2 months in warm weather to 10 months in cool weather. All stages are completed beneath or in the bark of infested trees, except for a brief period when the adults fly to find new trees to attack.

In the northern part of their range and at higher elevations, the beetles produce two generations each year, with attacks in early June and late August. In the South and at lower elevations, the beetles produce three and sometimes four generations each year, with attacks as early as March and as late as November.

During an attack period, which may last 3 weeks, each female lays about 60 tiny pearl-white eggs individually in niches cut into the sides of the egg gallery (fig. 6A). Some of these parent females may emerge and reattack to establish additional galleries elsewhere in the same tree or in other host trees. After incubating from 1 to 2 weeks, the eggs hatch.

The larvae are small white grubs that feed first in the phloem, where they construct a short gallery. They then mine into the middle bark where most of their development takes place (fig. 6B). After completing four larval stages, they transform into pupae and then into adults. As these brood adults feed on the middle and outer bark, fungal spores collect in their mycangia. Once the adult insects emerge, they are ready to renew the attack-infestation cycle in living trees.

When the female beetles successfully attack a tree, they release minute amounts of behavioral chemicals into the air. These odors (pheromones) attract males and other females to the tree, causing a mass attack that tends to overcome the tree's natural resistance. If numerous beetles are flying and fair weather persists, adjacent trees may be attacked, resulting in a group of infested trees. Usually, an



A F-703006

B F-703007

Figure 6.—*Life stages of the western pine beetle: (A) adult and eggs five times the natural size and (B) midstage larvae, natural size.*

insufficient number of beetles are flying, or bad weather delays the arrival of more beetles to the vicinity of the newly attacked tree. Either of these conditions will usually result in the typically isolated dead tree.

Besides attracting western pine beetles themselves, the pheromones also attract their natural enemies, such as predaceous checkered and ostomid beetles. The ability of these beetles to sense the pheromones makes them effective predators during the critical attack phase.

Conditions Affecting Outbreaks

Several conditions often work together to influence the number of beetles and the beetle-caused tree mortality in a given area. The significant conditions follow.

Food supply.—The availability of suitable host material—phloem and inner bark—is a key condition influencing western pine beetle outbreaks. Most trees are either too healthy or too weak to provide material in which beetle numbers can increase. Healthy trees can withstand many attacks before the beetles are successful, the brood is established, and new adult beetles are produced. Weak trees, such as those that have been smog damaged, diseased, or suppressed by competition, although easily killed, also produce relatively few beetles.

The thick, nutritious phloem and inner bark of healthy trees become host material for attacking western pine beetles when these trees undergo sudden and severe moisture stress. Healthy trees ordinarily produce abundant amounts of resin, which pitch out or eject attacking beetles. But, when suddenly deprived of moisture, stressed trees cannot produce sufficient resin flow to resist attack, and their nutritious food supply becomes available to beetles. In these trees, almost all attacking beetles can succeed and reproduce

many times their number of offspring, increasing the beetle population to outbreak levels.

Moisture stress results when the water balance between the foliage and the roots changes dramatically. An imbalance may result from increased water loss from the needles (transpiration), decreased water uptake by the roots (physiological drought), or from a combination of the two.

Any condition that results in excessive demand for moisture, such as tree crowding, competing vegetation, or sudden exposure to severe sunlight; or any condition that reduces the ability of the roots to supply water to the tree, such as mechanical root damage, root disease, soil compaction, or drought, can cause moisture stress and increase susceptibility to attack by the western pine beetle.

Loss of attacking beetles.—Flying adult beetles may fail to locate a suitable host tree or may fail to initiate attack once they arrive. Bark beetle losses during this period, which include losses from predation by checkered beetles, are nearly impossible to measure accurately, but they appear to be considerable.

Tree resistance.—Healthy pines produce sufficient resin flow at the attack site to (1) pitch out (eject) the beetles or (2) soak the phloem tissue surrounding the egg galleries with resin. The trees thereby inhibit larval and fungal development.

Natural enemies.—More than 80 species of predaceous and parasitic insects have been found in bark infested by the western pine beetle, but the nature of the relationships among them is largely unknown. Two important species of checkered beetles known to prey on the western pine beetle are *Enoclerus lecontei* (Wolcott) (fig. 7) and *Enoclerus sphegus* Fabricius. The blue-green ostomid *Temnochila chlorodia* Mannerheim and the fly *Medetera aldrichii* Wheeler are also important predators of the western pine beetle.

F-703008

Figure 7.—*Adult, black-bellied clerids* (Enoclerus lecontei) *feed on western pine beetles attacking the tree. Two times the natural size.*

Common parasites are *Roptrocerus xylophagorum* Ratzeburg, *Dinotiscus burkei* Crawford, and *Coeloides* sp. nr. *brunneri* Vierick.

Woodpeckers remove the outer bark from infested trees to feed on the larvae. Larvae that are not eaten are left with only a thin layer of protective bark, increasing their susceptibility to desiccation and parasitism.

Woodpeckers, predators, and parasites play a significant role in reducing the number of the developing brood within a tree. Although they help stabilize conditions at low beetle population levels, their action alone cannot control outbreaks.

Cold temperatures.—Winter temperatures below −20° F (−27° C) and persisting for several days can cause heavy brood mortality in those portions of the tree above the snowline. Effects are only temporary, however, and after a few generations, the population usually recovers.

Control

Landowners have two basic alternatives when choosing the control strategy most appropriate for their needs: beetle population suppression and damage prevention.

Suppression.—Over the years, several suppression methods have been tried to help reduce beetle populations enough to lower tree mortality significantly. These methods have included the removal of infested trees by logging, felling infested trees and peeling off and burning the bark, and felling infested trees and applying toxic residual sprays to kill emerging beetles. Because adult beetles can fly many miles and produce many offspring, effective suppression methods require the location (spotting) and treatment of all, or nearly all, infested trees over extensive areas in a short period of time.

Timely spotting and treatment are difficult and expensive tasks that require cooperation among many landowners. Consequently, the results have often been unsatisfactory. Also, these projects have failed because the basic underlying cause for the population outbreak—an abundance of stressed trees—has not changed. Typically, if a habitat favorable to high-level western pine beetle populations persists, suppression—by whatever means—will probably fail to reduce tree mortality significantly.

Prevention.—Where ponderosa and Coulter pine contribute appreciably to land value, such as in commercial forests, developed recreation sites, and urban forests, preventing tree killing by the western pine beetle is often more appropriate than attempting to suppress beetle populations. Landowners can prevent unacceptable damage on their land by maintaining thrifty, vigorous trees or stands that do not afford a suitable food supply for the beetle.

In mature pine forests east of the Cascade-Sierra Nevada crest, removal of trees with a great chance of damage by beetles in a program known as sanitation cutting can salvage valuable timber that might otherwise be lost if the trees were to die gradually. Trees with a high risk of damage by beetles characteristically have poor vigor and can be recognized by crown symptoms such as dead tops, branches, and twigs and short, sparse, poorly colored foliage. Also, they may be older, slow-growing trees that are heavily infected with dwarf mistletoe, that are root diseased, or that have been struck by lightning.

The thinning of dense, 70- to 80-year-old sawtimber stands is an effective silvicultural method for managers of both small and large holdings. Reducing stand stocking to 55 to 70 percent of the basal area needed for full site utilization will relieve the competitive stress among the remaining trees, improve their vigor, and make them less prone to successful bark beetle attack.

Prevention can also take the form of minimizing injury or disturbance to individual trees or sites. Careful logging practices and care in develop-

ing urban forest land are simple, yet effective, ways to prevent damage by western pine beetles.

Individual tress of particularly high value that are predisposed to beetle attack by temporary injury or disturbance may be given a protective residual bark spray to prevent successful attack. If protection for 1 or 2 years would allow the tree to regain its normal vigor, such spraying may be viable. The sprays are costly, however, and should not be considered if trees have a severe root disease, are badly injured by construction, or are seriously damaged in other ways.

Insecticide use is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by the Environmental Protection Agency. Persons contemplating insecticide use should obtain the names of materials currently registered. Private landowners can get information from a Cooperative Extension agent at their land-grant college, State agricultural experiment station, county Extension office, or their local State forestry office. Federal resource managers contemplating action against the western pine beetle should contact the Forest Pest Management Staff, Forest Service, U.S. Department of Agriculture, for assistance and advice.

The author thanks the Forest Pest Management Staff, Forest Service, U.S. Department of Agriculture, for assistance and advice.

References

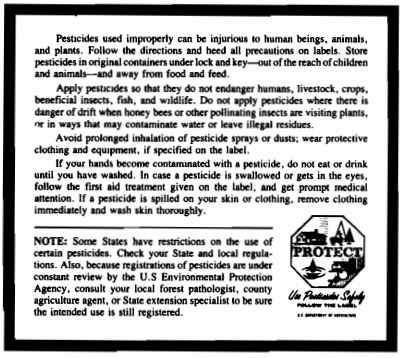
Koehler, C. S.; Wood, D. L.; Scarlett, A. L. Bark beetles in California trees. Coop. Ext. Leafl. 21034. Berkeley, CA: University of California, Cooperative Extension Service; 1978. 8 p.

Koerber, T. W., comp. Lindane in forestry ... a continuing controversy. Gen. Tech. Rep. PSW-14. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1976. 30 p.

Miller, J. M.; Keen, F. P. Biology and control of the western pine beetle. Misc. Publ. 800. Washington, DC: U.S. Department of Agriculture; 1960. 381 p.

Smith, R. H.; Trostle, G. C.; McCambridge, W. F. Protective spray tests on three species of bark beetles in the Western United States. J. Econ. Entomol. 70(1): 119-125; 1977.

Stark, R. W.; Dahlsten, D. L., eds. Studies on the population dynamics of the western pine beetle, *Dendroctonus brevicomis* LeConte (Coleoptera: Scolytidae). Berkeley, CA: University of California, Division of Agricultural Science; 1970. 174 p.


Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

PROTECT

Use Pesticides Safely

Revised
November 1982

☆ GPO : 1983 O - 416-953